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Theorizing spatial dynamics of metropolitan regions: A preliminary study in Java and Madura Islands, Indonesia



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ABSTRACT

This study is aimed at exploring the spatial dynamics of metropolitan regions in Java and Madura Islands, which are commonly known as the most developed areas in Indonesia. The analyses have used GIS-based and tabular data methods applying spreadsheet operations detailed at sub-district (*kecamatan*) level. An urban sub-district is defined as that with a built-up ratio of more than 22.5% and a population density of more than 1250 people/km2. Delineation of the built-up areas has used an unsupervised classification of 741-bands of Landsat TM7 satellite imageries for the years of 1990 and 2011. The potential sprawl is based on the comparison between the rate of population growth and that of built-up areas. The results show that generally, built-up areas significantly grow on the fringe zones of Java big cities. In metropolitan regions, an indication of non-compact growth occurs, albeit agricultural activities are still dominant there. Sprawl is found to be more in rural and outer than suburban and inner peripheral areas. In this regard, local governments should pay more attention to this issue because it can endanger the food security and environmental sustainability.

1. Introduction

The growth of Indonesian economy has been accompanied by high rate of urbanization in many regions, especially in Java and Madura Islands that are usually considered as the most rapidly growing region in Indonesia since the last several decades (Setyono, Yunus, & Giyarsih, 2016). As a consequence, there have been significant shifts in the use of land, from rural to urban dominant activities (Sugiri, Buchori, & Soetomo, 2011; Buchori and Sugiri, 2016; Buchori et al., 2015a, 2015b). Several big cities, such as Jakarta, Bandung, Semarang, Surakarta, Yogyakarta, Surabaya, and Malang, have been growing faster than others and influencing the smaller cities, and also their surrounding areas to become metropolitan. Jakarta, the capital of Indonesia that is often called megapolitan city due to its huge size, has been functionally expanding to its suburban areas, especially regarding hi-tech industries and multinational companies (Hudalah and Firman, 2012). It has also influenced Bandung metropolitan city, the capital of West Java province, to characterize an urban belt along the Jakarta-Bandung corridor of about 200 km, representing the fast growth of this mega-urban region (Firman, 2009).

Semarang, the capital of Central Java province, with its surrounding

cities has formed a metropolitan region called Kedungsepur. Located on the main road on the North side of Java (Pantai Utara/Pantura) connecting Jakarta and Surabaya, the city gets many benefits as well as the threat of unsustainability from the development (Buchori and Sugiri, 2016). Yogyakarta, the capital of the province of Yogyakarta Special Region located on the South side of central Java, has also been the center of Kertamantul metropolitan region, consisting of Yogyakarta city and two neighboring regencies, that is, Sleman and Bantul (Firman, 2010). The similar situation has also occurred in other big cities. Together with their adjacent cities and regencies, they have formed metropolitan regions. On the one hand, this situation may increase the economy of the regions, but on the other, it could endanger environmental sustainability, which could in turns lead to unsustainability (Sugiri et al., 2011). In the case of Jakarta Metropolitan Region (JMR), the development has indicated to increase spatial segregation among its areas (Firman, 2004).

In the regional and metropolitan context, concerns on economic growth may overlook environmental interests that make sustainable development not easy to be ensured. Spatial dynamics of a region significantly influence the performance of sustainable development of the region. In some cases, spatial dynamics in many Indonesian

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metropolitan regions show the tendency of unsustainability (Sugiri and Buchori, 2016; Sugiri et al., 2011; Buchori and Sugiri, 2016; Buchori et al., 2015a, 2015b; Firman, 2009).

Sustainable development aims at achieving intra- and inter-generational equity by ensuring that natural resource exploitations are done with full consideration of the rights of future generations (WCED, 1987). The Word Bank indicates three problems regarding land management issues in facing population growth and intensity of economic activities, that is, efficiency, sustainability and equity (Munashinge 1994). In this regard, regional planning is responsible for managing land uses to be socially optimal applying the principles of internalizing the externality and polluters pay (Sugiri and Buchori, 2016). Sustainable development should thus be considered as the main framework of community and social development, synchronizing the long term perspective of resource exploitation and the ecological concerns (Amir, Ghapar, Jamal, & Najiah, 2015).

A proper understanding of the spatial dynamics of a region is critical in helping policy makers to make the most appropriate policies relating to sustainable regional development. This paper, therefore, aims to explore the spatial dynamics of urban metropolitan regions in Java and Madura Islands (Fig. 1) commonly deemed as the most developed areas in Indonesia. The study area is differentiated into general and detail levels. The general level aims at giving general overview of spatial dynamics in the whole areas of Java and Madura. It consists of six provinces, i.e. the Special Capital Region of Jakarta, the Provinces of Banten, West Java, Central Java, East Java, and the Special Region of Yogyakarta. The detail level focuses to observe the metropolitan regions, which contains seven metropolitan regions, i.e. Jabodetabek (Jakarta, Bogor, Depok, Tangerang, and Bekasi), Bandung Raya (Bandung City, West Bandung, Sumedang, Cimahi, and Bandung Regency), Kedungsepur (Kendal, Demak, Ungaran or Semarang Regency, Semarang City, and Puwodadi), Subosukowonosraten (Surakarta, Boyolali, Sukoharjo, Karanganyar, Wonogiri, Sragen, and Klaten), Kartamantul (Yogyakarta, Sleman, and Bantul), Gerbangkertosusila (Gresik, Bangkalan, Mojokerto, Surabaya, Sidoarjo, and Lamongan), and Malang Raya (Batu City, Malang City and Malang Regency). The information for both levels of observations is detailed at sub-district level, based on three indicators, i.e., the shift of urban areas, the shift pattern of population density, and the distribution pattern of urban sprawl. The results are then theorized based on the empirical evidence found in the study area.

Adjusted as one of three pillars of geomatics and considered as the most powerful tool in spatial analyses. Geographic Information System (GIS) accompanied by Remote Sensing (RS) and Image Processing (IP) is often used to analyze spatial dynamics and changes of geographical phenomena (Khaddaj, Adamu, and Morad 2005; Xiao et al., 2006; Puertas, Henríquez, & Meza, 2014). Many such studies have been available, among which are the one evaluating urban expansion using GIS and remote sensing in Shijiazhuang China (Xiao et al., 2006), and the research analyzing dynamics of urban gentrification using cellular automata at Salt Lake City (Torrens and Nara, 2007). Meanwhile, the study of system dynamics and cellular automata modelling to assess urban growth applied in Shanghai (Han et al., 2009) and another that has dealt with analyzing urban sprawl using remote sensing in the megacity of Cairo (Taubenböck, Wegmann, Roth, Mehl, Dech. 2009) are also essential. More recent studies include those predicting and comparing urban growth using suitability index in South Korea (Park et al., 2011) and observing the spatiotemporal urbanization process in Mumbai using Markov-chains cellular automata model (Moghadam and Helbich, 2013). Other studies have developed multi-agent model to



Fig. 1. Study Area Location: Java and Madura by province and their metropolitan regions.

characterize land use dynamics applied in Brazilian Cerrado (Ralha et al., 2013), contrasted demographic and land use change to urban and suburban dynamics in Santiago (Banzhaf, Reyes-Paecke, Müller, & Kindler, 2013), and simulated urban growth based on neural network at the USA (Pijanowski et al., 2014). Moreover, another one has analyzed urban agglomeration impact in Malegaon, India (Poyil and Misra, 2015). A recent study developing GIS application to monitor sustainable rural development in Java by Buchori and Sukmawati (2015) may also count. Those studies have contributed in developing GIS/RS as the increasingly essential tool in urban and regional planning.

Urban and regional development can be measured by the rapid growth of economic development accompanied by other aspects such as social and environmental ones. To ensure sustainability and equity in the development, proper information on spatial dynamics is important. Since urban growth in developing countries like Indonesia is quite dynamics, the use of GIS with its capability to store, analyze and present spatial information precisely and accurately (Buchori, 2011) can support the work of local regional managers, that is, the governor, the mayor (*walikota*) and the regent (*bupati*) as the heads of sub-national and local governments.

2. Urbanization and urban sprawl

Urbanization has been an interesting social-economic phenomenon since the last decade, taking place on a surprising scale and rate all over the world (Sun, Wu, Lv, Yao, & Wei, 2012). It has also been becoming an important issue in the current studies of urban and regional planning, particularly relating to the development of metropolitan areas (Jiang et al., 2016). Urbanization represents a tendency of demographic change that has encouraged a comprehensive transformation process of land use changes (Grimm et al., 2008), covering urban and rural areas in the context of rural-urban linkage (Lambin et al., 2001). It can be associated with the rapid growth of population (Rukmana and Rudiarto, 2016) and the expansion of economic activities, especially in developing countries where the desire for prosperous economy significantly increases (Wu and Zhang, 2012).

Urban and rural areas have different characteristics. Bański and Mazur (2016) classify typological approaches to rural area based on location, structure and combination between them. Regarding the regional location to a city, Dijkstra and Poelman (2008) divide the typology of regions into five classifications, i.e. intermediate regions, intermediate regions close to a city, intermediate-remote regions, rural areas close to a city, and rural-remote regions. Scott, Gilbert, Gelan, and Carter (2007) argue that from the urban perspective, traditional stereotypical between rural and urban is the dominance of secondary and tertiary sectors. Other urban characteristics are the dominant activities in manufacturing, construction, administration and services, higher education level, better information accessibility, lower sense of community, lower fertility and higher mortality, more liberal political view, more varied ethnically, and higher in-migration. Furthermore, Law 26/ 2007 of Republic of Indonesia on Spatial Planning defines an urban area as a region having non-agricultural sectors as the main activities and structured as urban residential use, centralization and distribution of governmental and social services, and economic activities. Regarding these differences, to know spatial dynamics of a region needs to distinguish between urban and rural areas firstly.

Rural next to urban areas are described as places to live comfortably with the availability of nature, privacy and commuting, focusing on home-based activities. A rural center has a comparative advantage in the small-scale life, closely related to the economic benefits of smallness and closeness (Kuhmonen, Kuhmonen, and Luoto 2016). The relationships between rural and urban areas in the peri-urban zones shape a phenomenon widely known in Indonesia as *desakota* (McGee, 1991). Based on the functional terminology, there are differences between the characteristics of city center and rural hinterland that may affect the changes in income, poverty, and equality in these areas (Berdegué, Carriazo, Jara, Modrego, & Soloaga, 2015). Cities attract a significant amount of rural population, either as permanent or non-permanent migrants. A common case is that the wages earned in the city are remitted by the migrants to their motherland. Some of them use the wages to transform croplands and to create "remittance landscape" (Lambin et al., 2001).

Meanwhile, Coisnon, Oueslati, and Salanié 2014 concern to emphasize the role of agriculture in explaining the phenomenon of urban sprawl. Farms located close to urban areas seem to be more intensified, resulting in small agricultural amenities; while those in more distant locations tend to be more extensive, so that the provided agricultural amenities are relatively high. Many households prefer to accept the concept of long journey to work by living close to agricultural amenities. This situation may lead to the so-called "leapfrog" development (Coisnon et al., 2014).

United Nations' statistics in 2010 estimated that more than half population in the world lived in urban areas and was projected to reach 69.9% by 2050 (Wu and Zhang, 2012). According to United Nations (2014), the number of megacities in 2030 will significantly increase. About half of them will take place in Asia to accommodate 651 million populations (Pribadi and Pauleit, 2016). It happens because people intend to move to the cities aiming at seeking better economic opportunities to improve their quality of life (Soh 2012). The gap of quantity and quality of facilities between rural and urban areas and the thought that living in urban areas is more comfortable are adjusted as the reason for this.

Nowadays, the process of urbanization has occurred not only in urban but also in rural areas. It happens when the rural people shift their lifestyle to be more urbanized. It can be indicated by the change of jobs, from agriculture to non-agricultural sectors. The rapid growth of urban areas in Asian countries has triggered a large scale of conversions from agriculture to built-up areas. This phenomenon is then worsened by the tendency of declining population in the city centers (Pribadi and Pauleit, 2016). In this sense, urban development may represent regional economic wealth; however, the low density and "leapfrog" built-up patterns in suburban areas will potentially threaten environmental sustainability (Liu and Yang, 2015).

Urbanization is usually associated with demographic transitions. The process happens when the population is shifting from production to consumption-oriented societies. (Lambin et al., 2001). It also influences the changing process of socio-economic, cultural, ecological and environmental aspects (Wu and Zhang, 2012). The rapid growth of urbanization process has produced a diverse landscape with urban and rural land uses (Tsuchiya, Hara, & Thaitakoo, 2015). However, uncontrolled urbanization growth can significantly affect the quality of the environment.

The ecological balance in urban areas may be endangered by land conversions from agriculture, water reserved area, marsh area, forest, and grassland into built-up areas. It could be worsened by some common urban issues like waste water discharge and vehicle emission problems. This situation may lead to severe terrestrial, aquatic, and environmental degradation (Tan, Li, Xie, & Lu, 2005; Su, Gu, Yang, Chen, & Zhen, 2010; Deng et al., 2011; Zeng, Liu, Stein, & Jiao, 2015). It is, therefore, beneficial to ensure that the urbanization has less ecological consequences (Sun et al., 2012) by monitoring urban growth pattern and its change toward developing smart and eco-friendly solutions (Tsolakis and Anthopoulos, 2015). So, to enhance urban living quality, it is essential to support the process of decision-making by local government in urban land (Li, Zhao, & Xu, 2017) and resource management (Liu and Yang, 2015).

A critical issue that cannot be separated from urbanization is urban sprawl. It can be seen in the growth of low-density suburbs located in the peripheral areas of cities (Zeng et al., 2015) or in rural areas, which in many cases is usually inefficient and threatens the sustainability of urban development (Altieri, Cocchi, Pezzi, Scott, & Ventrucci, 2014).

Criteria of urban and rural classification.

Source: Head of National Statistics Agency Decree No. 37/2010 on Urban-Rural Classification in Indonesia, and the result of analysis, 2016.

Classification	Proportion of built-up areas	Population density
Rural	< 22.5%	< 1,250 people/km ²
Urban	≥22.5%	$\ge 1,250$ people/km ²

This issue has long been there in the literature. Salvati, Sateriano, and Bajocco (2013), for example, studying a Mediterranean City Region (Attica, Greece) using about five-decade period of chronological data, have found out that agricultural land has been the most probable one to be converted to built-up areas. A more recent study by Garouani et al. (2017) has also shown the negative impacts of a severe urban sprawl in Fez, Morocco, in terms of especially inefficient infrastructure provisions and conversion of green coverage and agricultural land into built-up areas. Similar findings are also resulted from another most recent study by Pili, Grigoriadis, Carlucci and Clemente (2017) focusing on the ecological consequences, which are negative, of the changing urban form due to sprawl in the same metropolitan region as that of Salvati et al. (2013), Attica, Greece.

Urban sprawl is observable visually. If a landscape is permeated by urban development of separate buildings or non-compact zones, it can be identified that it is suffered from urban sprawl. The degree of sprawl increases when the appearing urban areas have a more discrete pattern (Jaeger et al., 2010).

Also, by nature, urban sprawl is multi-dimensional and dynamics. A set of indicators has been developed by Zeng et al. (2015), concerning on growth rate, density, configuration, accessibility, open space, construction and aesthetics. Another set of indicators focuses on three metrics, i.e. fragmentation, compactness, and spatial configuration (Seto and Fragkias, 2005; Lv, Dai, & Sun, 2012; Zeng et al., 2015). Meanwhile, a study of Jiang et al. (2016) shows two stages during the sprawl process. In the first half period of their study, the residential land grew rapidly; while in the second half, industrial land tended to extend rapidly. The sprawl in residential land formed "radial sprawl", with a tendency of "living suburbanization". Furthermore, the commercial land tended to follow the pattern of "ribbon sprawl along the main roads". The sprawl of industrial land tended to be scattered in the pattern of "leapfrog sprawl" (Jiang et al., 2016). No matter what the shape is, an uncontrolled sprawling process will endanger the sustainability of the environment and regional development (Hosseinali Alesheikh, and Nourian 2013; Zeng et al., 2015).

3. Methods

This study focuses on observations of spatial change and sprawl patterns in the urbanized areas (metropolitan cities and their surrounding areas) with the help of GIS. The analysis contains two main stages, that is, to distinguish urban and rural areas, which in this case is detailed at sub-district level for the whole areas of Java and Madura and the years of 1990 and 2011, and to analyze the sprawl patterns, particularly in the regions surrounding the metropolitan cities in Java and Madura. The 2011 data is used because it was the newest satellite imagery information available for the whole Java and Madura when the study was firstly started in 2014.

The first stage is to distinguish urban and rural sub-district. Various indicators can be used for this purpose. OECD (2013) delimits urban areas by applying a threshold to identify densely inhabited grid cells, high-density urban clusters, and core municipalities. A functional urban area is defined if at least 15% of the population of a core commute to work to the other suburbs. Another method is urban zoning approach based on satellite imagery analysis. It aims at delineating urban areas by observing the structure of the urban pattern and morphology. It can

also be used to understand the dynamics and mechanism of the urban growth (Taubenböck, Esch, & Roth, 2006).

Meanwhile, Wirth (2008) has offered three indicators, that is, population size, density, and heterogeneity. However, the most often used indicators are the population density and the percentage of the built-up area. In line with this opinion, Pateman (2011) argues that population size is the commonly-used indicator. Several countries like Nepal, the US and India use population density, while the United Kingdom, Sweden and Brazil use built-up area (Bhagat, 2005). Another alternative method is by using both indicators. The study of Buchori et al. (2015a, 2015b) has already applied them for defining rural and urban areas in Java island, detailed at sub-district level. It defines an urban sub-district as that having population density more than 1250 people/ km2 and built-up area ratio more than 25%. Both criteria are used in this study; however, the threshold for the built-up area ratio is refined to 22.5% due to the equality of quantity of rural and urban sub-districts based on each criterion (see Table 1). However, those values are open to further elaboration and enhancement in other cases.

The data of the population size is available from the Central Bureau of Statistics (BPS). The population density is computed by dividing the population size with the area of the sub-district, which will be automatically measured by ArcGIS, the GIS software of ESRI used in this research. Based on the Head of National Statistics Agency Decree No. 37/2010, an urbanized area is defined as that with population density more than 1250 people/km2.

The identification of built-up areas uses a simple unsupervised classification technique of satellite image processing, based on the 741band combination of Landsat TM7. Manual digitation technique has been done in this process to be further executed by ArcGIS tools. By superimposing the built-up area with the sub-district administrative map, the map of the built-up area by sub-district is provided. The sub-district administrative boundary is gathered from the map of the National Agency for Geospatial Information (*Badan Informasi Geospatial/BIG*) on the scale of 1:25,000. The built-up area ratio is computed in the tabular data of ArcGIS, embedded in the resulted map. The urban sub-districts are those having built-up areas more than 22.5% of the total sub-districts are defined as those in agreement with both criteria. The shift of urban areas is analyzed by comparing the urban sub-district's maps in 1990 and 2011.

The second stage is to observe the sprawl patterns of the metropolitan regions by comparing them among the metropolitan regions. Various formulas can be used to measure sprawl index. However, this study uses a simple method because of the limitation of data. The distinction is based on the change of population and the built-up area from 1990 to 2011. A sub-district is categorized compact if the rate of the population growth is higher than that of the built-up areas. If on the contrary, it is categorized sprawl. In this study, administrative area expansion or separation occurred in many sub-districts during 1990–2011 is not considered. It is due mainly to the focus on the spatial dynamics that are more functional than administratively driven. The observation is based on two observation regions, i.e. province's base for general information and metropolitan region's base for more detail analysis, to systematize the structure of the analysis.

4. Analyses

4.1. Shift of built-up areas

The shift of built-up areas is analyzed based on the result of satellite imagery analysis for the years of 1990 and 2011, as shown in Fig. 2. In 1990, the built-up areas scattered in several big cities and their surrounding areas like Jakarta, Bandung, Semarang, Surakarta, Yogyakarta, Surabaya, and Malang. However, the built-up areas in Central Java and East Java look more spread out than those in other provinces. In the West part of Java (Banten, SCR of Jakarta, and West Java



Fig. 2. Built-up areas map of Java and Madura in 1990 (top) and 2011 (bottom). Source: Analyzed from Landsat TM7 satellite imagery

Province), the built-up areas in 2011 seemed to be persistently accumulated in Jakarta, Bandung and their surrounding areas. Only a few of them were separately seen in the South part of the region. It indicates that in the period of 1990–2011, the metropolitan area of Jakarta has dominated the development of the region.

A different situation occurred in the Eastern side of Java and Madura. In 1990, the built-up areas were accumulated in Surabaya City and its surrounding areas. However, it had been spreading out to the

The increase of built-up areas by province in Java and Madura from 1990 to 2011. Source: Own analysis.

Province	Built-up area in 1990 (km ²) Built-up area in 2011 (km ²)		Area (km ²)	Increase of built-up area (km ²)	Increase of built-up area (%)
Special Capital Region of Jakarta	439.27	585.47	664.48	146.19	22.00
West Java	5,630.44	6,735.05	37,938.56	1,104.60	2.91
Central Java	6,019.36	7,160.63	35,195.98	1,141.26	3.24
Special Region of Yogyakarta	609.58	958.28	3,255.66	348.70	10.71
East Java	5,978.55	8,929.93	48,313.76	2,951.38	6.11
Banten	-	1,434.67	9,686.13	1,434.67	14.81
Total	18,677.21	25,804.02	135,054.58	7,126.81	5.28

southern side of the region, along to the Malang City and its surrounding areas during 1990–2011. At the same period, the development of built-up areas in Central Java and SR of Yogyakarta also looked more spread out to the entire regions than those in the Western side of the Island. The growth of Yogyakarta City as the capital of the Special Region has significantly penetrated its surrounding regions. The extent has crossed the boundaries of regencies and cities belonging to Central Java Province.

Furthermore, Table 2 shows the change of built-up areas from 1990 to 2011. The total built-up area in Java and Madura in 1990 was accounted for 9,839.74 km², dominated by East Java Province (41%) and Central Java Province (33%). It increased 10.31% or 13,929.06 km² in 2011–23,768.8 km². The higher increase (more than 10%) occurred in the Special Capital Region (SCR) of Jakarta, the Special Region (SR) of Yogyakarta, and Banten.

Notes: Jabodetabek (Jakarta, Bogor, Depok, Tangerang, and Bekasi), Bandung Raya (Bandung City, West Bandung, Sumedang, Cimahi, and Bandung Regency), Kedungsepur (Kendal, Demak, Ungaran or Semarang Regency, Semarang City, and Purwodadi), Subosukowonosraten (Surakarta, Boyolali, Sukoharjo, Karanganyar, Wonogiri, Sragen, and Klaten), Kartamantul (Yogyakarta, Sleman, and Bantul), Gerbangkertosusila (Gresik, Bangkalan, Mojokerto, Surabaya, Sidoarjo, and Lamongan), and Malang Raya (Batu Regency, Malang City and Malang Regency)

Meanwhile, Table 3 shows the shift of built-up area by metropolitan region. Although the largest increase occurs in Jabodetabek, the highest percentage of increase is Kertamantul, followed by Bandung Raya. As for Bandung Raya, the significant growth seems to be an impact of the continuing urbanization in the corridor of Jakarta Bandung Region (JBR).

4.2. Classification of urban and rural sub-districts

Two diagrams in Fig. 3 show the number of sub-districts classified as rural and urban in 1990 and 2011 based on population density and built-up area. It reveals that the number of urban sub-districts increased based on both criteria. However, those based on built-up area look higher than those based on population density both in 1990 and 2011. The query to the database shows that this difference was caused by two main factors. The first factor is the expansion of urban administrative

areas, based on which several sub-districts on urban fringe areas were divided into two or more sub-districts. The second one is the acquirement by several cities of some sub-districts located in the adjacent parts of their neighbor regencies.

Furthermore, Table 4 shows the result of the classification of urban and rural sub-districts in Java and Madura in 1990 and 2011. Based on the population density in 1990, the urban sub-districts were accounted for 29.84% of the total sub-districts. It grew about 7.5% to 38.38% in 2011. Meanwhile, those based on the built-up area in 1990 were accounted for 30.00% and increased to 46.94% in 2011. The higher number of urban sub-districts based on the built-up area than those based on the population density indicates the occurrence of sprawl phenomenon. It appeared especially in the fringe areas of the Java metropolitan cities like Jakarta, Bandung, Semarang, Solo, and Surabaya.

As for the spatial distribution, Fig. 4 shows the maps of rural and urban sub-districts of Java and Madura in 1990 and 2011. The appearance of new urban sub-districts was usually located in the fringe areas of metropolitan cities like Jakarta, Bandung, Semarang, Surakarta, Yogyakarta, Surabaya, and Malang. Furthermore, Table 3 shows that based on both criteria, the total number of urban sub-districts increased about 10.47% during 1990–2011. In this case, the rural sub-districts surrounding big cities had become urban. The increase of the percentage of urban sub-districts categorized by population density indicates an urbanization process mainly caused by people movement form rural to more urbanized areas in the big cities' fringe areas.

Table 5 shows the result of the classification of sub-districts that belong to metropolitan regions. The growth of the percentage of urban sub-districts in metropolitan regions is higher than that of the whole Java and Madura. In other words, the urbanization process in the metropolitan regions grows faster than that outside them. However, the interesting fact is that the delta percentage of urban sub-districts based on the built-up area is twice as higher as that based on the population density. It is an indication that the urban growth in metropolitan regions tends to be non-compact and can consume land unnecessarily.

Furthermore, Table 6 shows the classification of urban and rural sub-districts by metropolitan regions. The proportion of urban subdistricts increased at about 3% during 1990–2011. The significant increase occurred in Malang Raya, Bandung Raya, Jabodetabek, and Gerbangkertosusila. An interesting fact found in Subosukowonosraten

Table 3

The increase of built-up areas metropolitan regions of Java and Madura from 1990 to 2011. Source: Own analysis.

Province	Built-up area in 1990 (km ²)	Built-up area in2011 (km ²)	Area (km ²)	Increase of built-up area (km ²)	Increase of built-up area (%)
Jabodetabek	1,875.81	2,763.53	6,964.72	887.72	47.32
Bandung Raya	514.47	893.40	4,751.57	378.93	73.65
Kedungsepur	1,098.00	1,210.39	5,605.17	112.39	10.24
Subosukowonosraten	1,396.00	1,526.74	5,270.45	130.74	9.37
Kertamantul	266.33	487.68	1,151.65	221.35	83.11
Gerbangkertosusila	943.64	1,384.51	6,336.03	440.87	46.72
Malang Raya	495.31	703.97	3,780.30	208.66	42.13
Total	6,589.56	8,970.22	2,380.66	2,380.66	36.13



Fig. 3. Classification of sub-districts based on population density and built-up areas in 1990 (left) and 2011 (right). Source: Own analysis.

Table 4

Classification of urban and rural sub-district in Java and Madura based on population density and built-up area in 1990 and 2011. Source: Own analysis.

Criteria	Sub-districts in 1990		Total sub-districts in 1990	Sub-districts in 2011		Total sub-districts in 2011
	Urban	Rural		Urban	Rural	
Built-up area	532	1,251	1,783	965	1,091	2,056
	(29.84%)	(70.16%)	(100.00%)	(46.93%)	(53.06%)	(100.00%)
Population density	554	1,229	1,783	789	1,267	2,056
	(31.07%)	(68.93%)	(100.00%)	(38.38%)	(61.62%)	(100.00%)
Built-up area AND population density	364	1,419	1,783	635	1,421	2,056
	(20.42%)	(79.58%)	(100.00%)	(30.89%)	(69.11%)	(100.00%)

and Kedungsepur was the decrease of urban sub-districts during 1990–2011. In Subosukowonosraten it even reached -46%.

4.3. Sprawl pattern by sub-district

The result of sprawl classification by sub-district during 1990–2011 is as shown in Table 7. Most of the sub-districts (71.0%) are sprawling. The number of sprawl sub-districts in rural areas is also higher than that in urban areas. The analysis shows that SR of Yogyakarta has the highest number of sprawl sub-districts (77.8%), followed East Java (75.0) and West Java Provinces (70.0%). Among the six provinces, SCR of Jakarta has the lowest number of sprawl sub-districts (less than 50%), which represents its intensive development. Besides, only SCR of Jakarta has no rural sub districts.

Meanwhile, Fig. 5 shows the maps of spatial distribution of sprawl and compact sub-districts in metropolitan regions and the whole Java and Madura Islands. Many sub-districts located in the fringe areas of most metropolitan cities like SCR of Jakarta, Bandung, Semarang, Yogyakarta, and Surabaya tended to sprawl. The sprawl of Jakarta leads to Bekasi, Bogor and Tangerang while the sprawl tendency of Bandung City spread evenly to all directions of Bandung Raya.

In Central Java Province, the sprawl sub-districts were mainly located in the North Coastal cities like Brebes, Tegal City, Pemalang, Pekalongan City, Kendal, Semarang City, Kudus, Pati, and Rembang. Other regencies having significant sprawl sub-districts were Banyumas, Boyolali, Surakarta, Klaten, and Magelang City. Furthermore, in East Java Province, the sprawl pattern lead to the Western side of Surabaya, along to Sidoarjo, Mojokerto, Pasuruan, Jombang, Nganjuk, and Kediri. In the South side of the province, sprawl sub-districts appear in Malang, Blitar, Tulungagung, and several regencies in the North coastal areas like Pasuruan, Probolinggo, and Banyuwangi. However, there is no spatial pattern of sprawl sub-districts in rural areas. Overall, the sprawl sub-districts were more widely grown in rural areas.

Table 8 shows the tendency of sprawl by urban and rural sub-districts and metropolitan regions during 1990–2011. Almost half of the total sub-districts (45.9%) in metropolitan regions are rural. It means that agricultural activities are still dominant. An interesting fact occurs in Kedungsepur and Subosukowonosraten, which their number of urban sub-districts is much lower than rural sub-districts. In that period, Kartamantul had the highest proportion of sprawl sub-districts (77.1%), followed by Gerbangkertasusila (76.6%) and Kedungsepur (72.3%). The lowest proportion occurred in Jabodetabek, which was just accounted for 47.7%. It indicates that the development of Jabodetabek is more intensive than that of the others.

It can be said that 76.4% of rural sub-districts in metropolitan regions were potentially sprawl. The highest proportion occurred in Kertamantul (92.8%), followed by Gerbangkertasusila (81.8%) and Malang Raya (80.0%). It means that rural areas need special attention for their development. The highest absolute number of rural sub-districts being potentially sprawl also occurred in Gerbangkertasusila (54 sub-districts). The lowest proportion was in Jabodetabek.

Fig. 6 shows the spatial distribution of compact and sprawl subdistricts in the seven metropolitan regions. As shown in the map, the patterns are mix and spread. However, the core sub-districts of Jabodetabek seem to be more compact than those of the others.

5. Discussions

5.1. Three clustered patterns of spatial dynamics

This study reveals three clustered patterns of spatial dynamics regarding the metropolitan development of Java and Madura Islands. The fast-growing process of urbanization in big cities like Jakarta, Bandung, Semarang, Surakarta, Yogyakarta, Surabaya, and Malang has significantly triggered the development of their surrounding areas, which in turn extended the functional areas of metropolitan cities. According to the shift of the built-up areas, the growth of the western and eastern parts of Java is faster than that of the central part, disclosing the three patterns. This phenomenon seems to be affected by the role of Jakarta and Surabaya as important growth centers spurring the development of



Fig. 4. Classification of urban and rural sub-district of Java and Madura based on population density and built-up area in 1990 (top) and 2011 (bottom). Source: Own analysis.

Classification of urban and rural sub-district in metropolitan regions of Java and Madura in 1990 and 2011. Source: Own analysis.

Criteria	Sub-districts in 1990		Total sub-districts in 1990	Sub-districts in 2011		Total sub-districts in 2011
	Urban	Rural		Urban	Rural	
Built-up area	324 (51.35%)	307 (48.65%)	631	483 (69.90%)	208 (30.10%)	691
Population density	316 (50.08%)	315 (49.92%)	631	412 (59.62%)	278 (40.37%)	691
Built-up area AND population density	252 (39.94%)	379 (60.04%)	631	377 (54.56%)	314 (45.44%)	691

their surroundings. Among all growth centers, Jakarta is the most influential city followed by Surabaya with a slightly lower intensity.

The first pattern is that of the western part of Java, which tends to show an obvious attraction of the core cities. The built-up areas in 2011 were accumulated in Jakarta, Bandung, and their surroundings with less intensity in the southern part of the region. The high-growth of urban sub-districts in the metropolitans of Jabodetabek and Bandung Raya is mainly due to their function as the development center of Java and Madura, and even, Indonesia. This finding confirms the studies of Firman (2009) and Hudalah and Firman (2012), which found out that Jakarta has been functionally expanding to its suburban areas, so much so that forms an urban belt along the Jakarta-Bandung corridor of about 200 km.

Secondly, another obvious attraction of core cities, albeit with less intense, occurs in the eastern part of Java and Madura. The built-up areas in 2011 were accumulated in Surabaya, spreading out to the southern side of the region, along to Malang and its surroundings. In terms of the increase of urban sub-districts, the growth of Gerbangkertosusila with Surabaya as the core has reinforced its position as the second-biggest growth center after Jakarta. Meanwhile, the urban sub-districts in Malang Raya as a "young" metropolitan region also show significant growth, although its absolute number is still relatively low.

Thirdly, the spreading growth of the central part of Java is influenced by the role of Semarang and Yogyakarta significantly. It is worth noting that several medium-sized cities in Pantura like Tegal and Pekalongan, and in the two corridors connecting Yogyakarta and Semarang, that is, Magelang and Surakarta, have also contributed to the growth of the region. During 1990–2011, the development of built-up areas in the provinces of Central Java and SR of Yogyakarta had looked more spread out to the entire regions than those in the western and eastern side of the Island. In this regard, a question whether the growth of the built-up areas takes effect to the spatial disparity is interesting to be further studied.

Another interesting finding regarding this third pattern is the decrease of urban sub-districts in Subosukowonosraten and Kedungsepur. The data query showed a loss of population in many sub-districts of the sub-regions, particularly Wonogiri of Subosukowonosraten, as the main cause. A public issue that many productive-age people from this region have moved to Jakarta to find a better job seems to be one of the reasons. This phenomenon has also occurred in the sub-regions of Kedungsepur.

5.2. Extensive sprawl on rural and outer peripheral areas

A tendency to sprawl is there in not only urban but also rural subdistricts. The data shows that 71% sub-districts of Java-Madura are potentially sprawling. The proportion of sprawl in rural sub-districts is higher than that in urban sub-districts. Among the six provinces, SCR of Jakarta is the only province that the proportion of sprawl sub-districts is less than 50%. This fact confirms the indication of the tendency of unsustainability in Java metropolitan regions resulted from the studies by Sugiri et al. (2011), Buchori and Sugiri (2016), Buchori et al. (2015a, 2015b), Firman (2009), and Sugiri and Buchori (2016).

In the observed metropolitan regions, almost half of the total subdistricts (45.9%) are rural. A large amount of them (67.5%) is potentially sprawling. As recognized, 60.4% of the urban and 76.4% of the rural sub-districts in the metropolitan regions were potentially sprawl. It indicates that sprawl has been more intensively happening on rural than urban sub-districts. Besides, its occurrence is more on outer than inner peripheral areas. This fact is in agreement with the statement of Zeng et al. (2015) and Altieri et al. (2014), that is, urban sprawl is

Table 6

Classification of urban and rural sub-district by metropolitan regions of Java and Madura based on population density and built-up area in 1990 and 2011. Source: Own analysis.

Criteria	Sub-districts in 1990		Total sub-districts in 1990	Sub-districts in 202	11	Total sub-districts in 2011
	Urban	Rural		Urban	Rural	
Jabodetabek	96 (67.60%)	46 (32.40%)	142	139 (76.79%)	42 (23.21%)	181
Bandung Raya	31 (36.90%)	53 (63.10%)	84	54 (59.34%)	37 (40.66%)	91
Kedungsepur	34 (40.96%)	49 (59.04%)	83	28 (31.46%)	61 (68.54%)	89
Subosukowonosraten	80 (74.07%)	28 (25.93%)	108	43 (39.45%)	66 (60.55%)	109
Kertamantul	31 (64.58%)	17 (35.42%)	48	34 (70.83%)	14 (29.17%)	48
Gerbangkertosusila	46 (36.51%)	80 (63.49%)	126	64 (48.48%)	68 (51.52%)	132
Malang Raya	6 (15.00%)	34 (85.00%)	40	15 (36.59%)	26 (63.41%)	41
Total	324 (51.35%)	307 (48.65%)	631	377 (54.56%)	314 (45.44%)	691

Sprawl tendency by sub-district in urban and rural sub-districts during 1990–2011. Source: Own analysis.

Province	Urban		Total urban sub-districts	Rural		Total rural sub-districts	Sprawl	Compact	Total sub-districts
	Sprawl	Compact		Sprawl	Compact				
Central Java	103	51	154	264	112	376	367	163	530
East Java	108	40	148	349	(29.8%)	461	(69.2%) 457	(30.8%)	609
West Java	(73.0%) 91	(27.0%) 52	143	(75.7%) 222	(24.3%) 68	290	(75.0%) 313	(25.0%) 120	433
Banten	(63.6%) 12	(36.4%) 16	28	(76.5%) 38	(23.5%) 26	64	(72.3%) 50	(27.7%) 42	92
SCR of Jakarta	(42.8%) 20	(57.2%) 23	43	(59.4%) 0	(40.6%) 0	0	(54.3%) 20	(45.7%) 23	43
SR of Yogyakarta	(46.5%) 24	(53.5%) 10	34	0% 32	0% 6	38	(46.5%) 56	(53.5%) 16	72
Tetel	(70.5%)	(29.5%)	550	(84.2%)	(15.8%)	1 000	(77.8%)	(22.2%)	1 570
10(81	358 (65.1%)	(34.9%)	(30.1%)	905 (73.6%)	324 (26.4%)	(69.9%)	(71.0%)	(29.0%)	(100.0%)

usually located in the peripheral of cities and rural areas, which sequentially implies to rise to inefficiency concerning urban development. However, the higher level of sprawl in rural than urban sub-districts could indicate a potential threat to the environment.

The sprawling process in Java and Madura tends to be more extensive in rural and inner than urban and outer peripheral areas. Although urbanization in the core cities of the metropolitan regions proceeds significantly, it has not been fully followed by their fringe and surrounding areas. At least, a non-compact urban growth has been happening, and it can, in turn, waste the land resources. This phenomenon is potentially worsening the leapfrog growth in the region. Therefore, local governments should be encouraged to be more aware on this issue because it can endanger the food security and environmental sustainability.

5.3. De-urbanization of outer suburbs in central Java province

Another significant finding is the phenomenon of de-urbanization in two metropolitan regions of Central Java Province, that is, Kedungsepur and Subosukowonosraten. During 1990-2011, the number of urban sub-districts of those metropolitan regions has significantly decreased, which in Subosukowonosraten even reached -46%. In term of built-up areas, their increase just reached about 10% during 1990-2011, far below the average of other metropolitan regions (at about 50-60%). Even when their built-up areas slightly increased, many sub-districts were experiencing a decrease in the population. Urbanization in bigger metropolitan cities like Jakarta, Bandung, and Surabaya was probably the trigger of this phenomenon. They seemed to look "sexy" in the eyes of the society, especially the youngsters. Significant pulled factors were attributed concerning improved economic conditions, better access to facilities and diversity of social structures. This evidence was especially found in the regencies situated on the outer areas of Kedungsepur and Subosukowonosranten, which urban sub-districts were accounted much lower than rural sub-districts. In those regions, the decrease of population density has instigated many sub-districts categorized as urban in 1990 changing into rural in 2011

Meanwhile, an interesting phenomenon was found in Kertamantul, the other metropolitan region located in the central part of Java belonging to SR of Yogyakarta Province. Its built-up areas had grown at the highest rate (86.11%) compared to the other metropolitan regions during 1990–2011. In this regard, the fast growth of Yogyakarta, besides Jakarta and Surabaya, may also be the reason why de-urbanization occurred in Kedungsepur and Subosukowonosraten. It is also in line with the fact that in terms of built-up areas, the growth of Yogyakarta has significantly penetrated its surrounding regions, crossing the boundaries of regencies and cities belonging to Central Java Province.

5.4. Implications for planning

The implications of spatial dynamics to planning can be summarized regarding the three parts of Java and Madura regions. In the western part, the dominant function of Jakarta potentially endangers environmental sustainability. As recognized, a primate city can absorb an unreasonable amount of resources. In this regard, the dominance of Jakarta and Bandung representing the core development of SCR of Jakarta and West Java Province can trigger uneven growth and prosperity distribution. Controlling the development of Jabodetabek, Bandung Raya, and especially the fast-growing corridor between Jakarta and Bandung is therefore necessary. It can also be driven to the western side of the region, aiming to stimulate the development of the regencies and cities belonging to Banten Province, many of which are still in less-developed conditions.

In the central part, the phenomenon of de-urbanization in the two metropolitan regions of Central Java Province should be considered as a potential inefficiency of regional development. The extent of built-up areas without accorded by population density in the rural and outer peripheral areas of the metropolitan regions may affect to an inefficiency and high cost in the development of regional infrastructure. The development of "Joglosemar", a triangle corridor between Semarang, Solo (Surakarta), and Yogyakarta, can be set as a growth region evoking the regional development of the central part of Java and Madura.

The same development pattern with a rather lower intensity as that in the western part of Java and Madura occurs in the eastern part. In this region, Surabaya, the main city of this region, has established a fast-developing corridor directing to Malang on the southern side and bridging to Madura Island in the northern side. For this, a similar policy to that applied in Jabodetabek and Bandung Raya in controlling the development of Gerbangkertosusilo and Malang Raya may be applied.

At the nearly same time, post-suburban transformation in SCR of Jakarta has contributed to the improvement of its economic performance, involving a de-concentration of high technology (hi-tech) industries and multinational companies, converting formerly neglected rural hinterland into planned suburban industrial estates (Hudalah and Firman, 2012). In this case, the suburban areas are now being transformed into new urban centers completed with major commercial, leisure and cultural facilities (Hudalah and Firman, 2012). However, alongside with this transformation, sustainability issues have also arisen. Recent studies in other urban and metropolitan regions (Salvati et al., 2013; Buchori et al., 2015b; Buchori and Sugiri, 2016; Garouani et al., 2017; Pili et al., 2017) have confirmed these issues so, it



Fig. 5. Tendency of sprawl pattern in urban and rural sub-districts. Source: Own analysis.

Sprawl tendency by sub-district in metropolitan regions of Java and Madura during 1990–2011. Source: Own analysis.

Metropolitan region	Urban		Total urban sub-districts	s Rural		Total rural sub-districts	Sprawl	Compact	Total sub-districts
	Sprawl	Compact		Sprawl	Compact				
Jabodetabek	46 (44.7%)	57 (55.3%)	103	17 (58.6%)	12 (41.4%)	29	63 (47.7%)	69 (52.3%)	132
Bandung Raya	32 (65.3%)	17 (34.7%)	49	25 (78.1%)	7 (21.9%)	32	57 (70.4%)	24 (29.6%)	81
Kedungsepur	15 (60.0%)	10 (40.0%)	25	45 (77.6%)	13 (22.4%)	58	60 (72.3%)	23 (27.7%)	83
Subosukowonosraten	28 (68.3%)	13 (31.7%)	41	46 (71.9%)	18 (28.1%)	64	74 (70.5%)	31 (29.5%)	105
Kartamantul	24 (70.6%)	10 (29.4%)	34	13 (92.8%)	1 (7.2%)	14	37 (77.1%)	11 (22.9%)	48
Gerbangkertasusila	41 (70.7%)	17 (29.3%)	58	54 (81.8%)	12 (18.2%)	66	95 (76.6%)	29 (23.4%)	124
Malang Raya	8 (53.3%)	7 (46.7%)	15	20 (80.0%)	5 (20.0%)	25	28 (70.0%)	12 (30.0%)	40
Total	198 (60.4%)	130 (59.1%)	328 (53.2%)	220 (76.4%)	63 (24.0%)	288 (46.7%)	416 (67.5%)	197 (32.0%)	616 (100.0%)

can be said, that threats of unsustainability have almost been common accompanying metropolitanization, especially in developing countries. Among the consequences is the severe conversion of agricultural land to built-up areas, and this would most probably threaten food security of a country that still relies on natural resources like Indonesia.

To anticipate those arising issues, a scheme of reforming policy in urban land utilization based on the principles of equity and sustainability proposed by Firman (2005) can be considered. It contains five points to address the issues of urban land development, i.e. land ownerships and transfers, land use development, land taxation, land development institutions, and land administration. This scheme is aimed at designing an effective, efficient, and equitable land resource management, which is in line with the idea that compact development is more efficient and sustainable than sprawl development that can compromise the lands. For this, urban and regional planners should be aware of these important issues: development of rural regions located outside the metropolitan regions having significant increase of land use conversion to built-up areas, ruralization of the sub-districts in metropolitan regions potentially obstructing regional development, and balance of development among regions regarding the principles of



Fig. 6. Spatial distribution of compact and sprawl sub-districts in the metropolitan regions. Source: Own analysis.

equity and sustainability.

Another awareness for planners is on developing rural non-farm activities, which should be in small scale units and labor intensive. The significance is twofold as can be inferred from a study by (Sugiri, Buchori, & Ma'rif, 2015) applying equity based development on the case in Susukan suburb of Semarang Metropolitan Region. First, the strategy is applicable to address the decreasing agricultural land due to the conversion with one condition, i.e., participatory planning and development. In the Susukan case, the non-farm potential has come up along with the conversion through a bottom-up mechanism, so the development should also apply participatory approach. The second one, as indicated previously that sprawl in rural areas has been occurring in central part of Java, the non-farm development can reverse the tendency of stagnant rural centers.

Achieving sustainable development should balance and connect among social, economic and ecological sectors (WCED, 1987). Such sustainability issues as regional imbalance, infrastructure mismatch, physical fragmentation, social segregation, and environmental degradation have become familiar in these metropolitan regions (Hudalah and Firman, 2012). Connecting and integrating various sectoral policies, like agriculture, energy, trade or other investment sectors, have been becoming another challenge to the local governments. Therefore, stepping forward to real action on making better planning coordination and innovative policy in all sectoral agencies is consequently necessary, most importantly when it is related to key private sectors and stakeholders.

6. Conclusion

This study has successfully theorized the empirical facts of spatial dynamics in Java and Madura Islands, Indonesia. In the western and eastern parts, the areas and metropolitan regions tended to intensively grow, triggered by the role of Jakarta and Surabaya as the core of development, even in the national context. A much lower intensity of growth occurred in the central part, indicated by the occurrence of deurbanization phenomenon in the metropolitan regions of Central Java Province. However, the metropolitan region of Kertamantul with Yogyakarta as the core city has become a growth pole in the southern side of central Java. Together with Jakarta and Surabaya, its urbanization process can attract the people to move there and extent its built-up areas to its surroundings.

Other than in Jabodetabek, the sprawling process tended to be more extensive in the rural and outer peripheral areas. Almost half sub-districts in the metropolitan regions are rural and potentials to sprawl. The extent of built-up areas has been establishing a "leapfrog" pattern, by randomly filling the areas in the rural sub-districts directing to the outer peripheral areas. This phenomenon is perhaps one stage in a metropolitan formation, which followed by fulfilling the spaces between the core cities and their surrounding built-up areas. However, if not carefully managed, it will endanger food security and environmental sustainability because of the loss of productive lands for food agriculture. This piece of evidence indicates a non-compact development that should be considered a crucial issue.

Inevitably, built-up areas will continue to grow as the impact of development. In this regard, mapping potentially sprawl areas as done in this study is useful for local authorities in prioritizing regional development. They can develop suitable policies that can lead to sustainable development. If left uncontrolled, the future of the region can be unsustainable and proceed to environmental degradation. For this, local government authorities should pay more attention to sub-districts located close to the core of metropolitan regions classified as rural and, conversely, sub-districts located far from the core city classified as urban. Even though this phenomenon is not always a failure of development, local governments should consider this as a tendency of noncompact development of the metropolitan regions. The fact that rural areas in Java are usually fertile agricultural lands, especially for wet land rice, makes the land conversion from agricultural lands to built-up areas would decrease food production. Besides, the existence of rural sub-districts administratively belonging to a city indicates a non-compact city that impact on inefficiencies in the provision of urban facilities and infrastructures. Lastly, the phenomenon of de-urbanization is interesting to be further studied in order to understand what has really been happening there. It is important to guarantee the objectives of equity and sustainability of regional development.

As for GIS, remote sensing, and image processing as the main supporting tools, they have proven to be appropriate in providing spatial information and describing spatial dynamics of a region. In this study, the data unit detailed at the sub-district level has spatially shown how the regions grow, the sprawl spreads, and the tendency of unsustainability occurs. The well-managed data and information provided in GIS format are certainly beneficial to support local authorities in managing their regions. However, it was revealed that data availability has become the main obstacle in this study. Therefore, the government should enhance the availability of standardized data in every regency/city level all over Indonesia, especially Java and Madura that are considered as the most developed areas in Indonesia.

Finally, it is realized that besides urbanization, other factors relating to socio-economic conditions can significantly drive urban sprawl and spatial dynamics of metropolitans. The use of diverse variables from industry sector and local land use can improve the result of the study. Adding other indicators of socio-economic conditions in further studies is therefore essential. However, it is not easy to obtain the required data of more than 2000 sub-districts located in 85 regencies and 33 cities. In Indonesia, the statistical data by sub-district is available in the data book of every regency/city level; unfortunately, the content has not been standardized, so it is quite often that certain information can be found in certain regencies/cities but not in the others.

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